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(54) **METHODS AND APPARATUS FOR FLEXIBLE DEVICE INTERFACE PORT ASSIGNMENT IN A DATA COMMUNICATIONS SWITCHING SYSTEM**

(75) Inventors: **Gordon K. Ngo**, Plano, TX (US); **Se Hyeon Rhee**, Seoul (KR); **Senthil Kumar Viswanathan**, Richardson, TX (US)

(73) Assignee: **Samsung Electronics Co., Ltd.**, Suwon (KR)

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(52) **U.S. Cl.** **370/386**; 370/375.1; 370/465

(58) **Field of Search** 370/367, 395.1, 370/396, 398, 395.2, 395.3, 395.5, 412, 413, 414, 417, 465, 386, 387, 388, 385; 340/2.27, 2.28, 2.21; 379/219, 271, 291, 335

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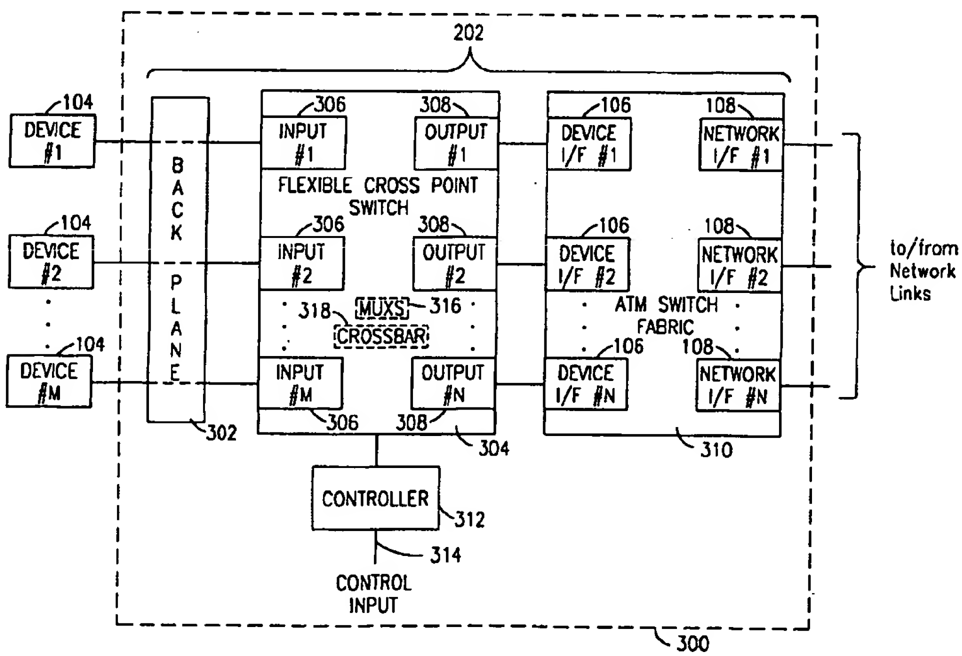
Primary Examiner—Chau Nguyen
Assistant Examiner—Andy Lee

(57) **ABSTRACT**

Methods and apparatus are provided for use in an ATM network that allow several devices to access a limited number of device interface ports in a ATM switch fabric, by providing flexible assignment of the limited ports. The methods and apparatus are dynamically configurable to permit port assignments to be changed on the fly, without interfering with existing communications. In certain embodiments a programmable MxN cross point switch is provided between M number of devices and a NxN ATM switch matrix. The cross point switch allows two or more devices to switchably access one or more of the device interface ports in the ATM switch matrix. The assignment of devices to device interface ports can be initiated manually or automatically by local and/or external control processes/devices.

20 Claims, 3 Drawing Sheets



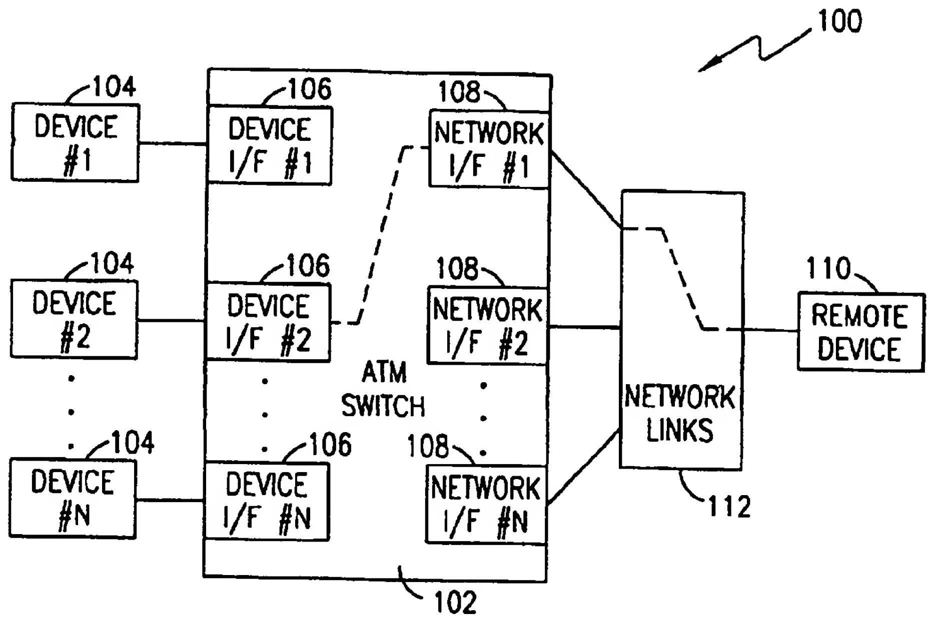


FIG. 1
(Prior Art)

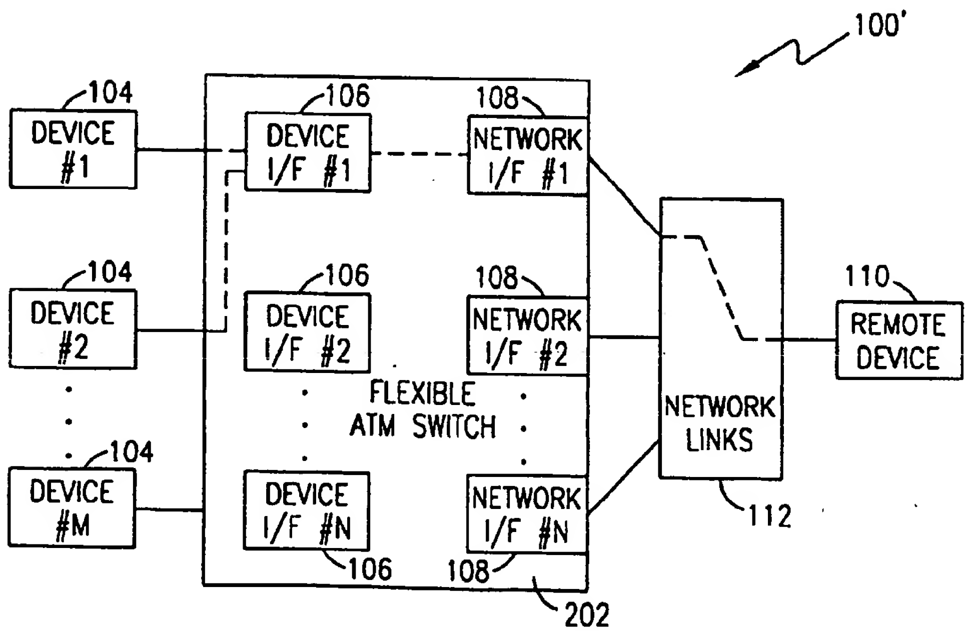


FIG. 2

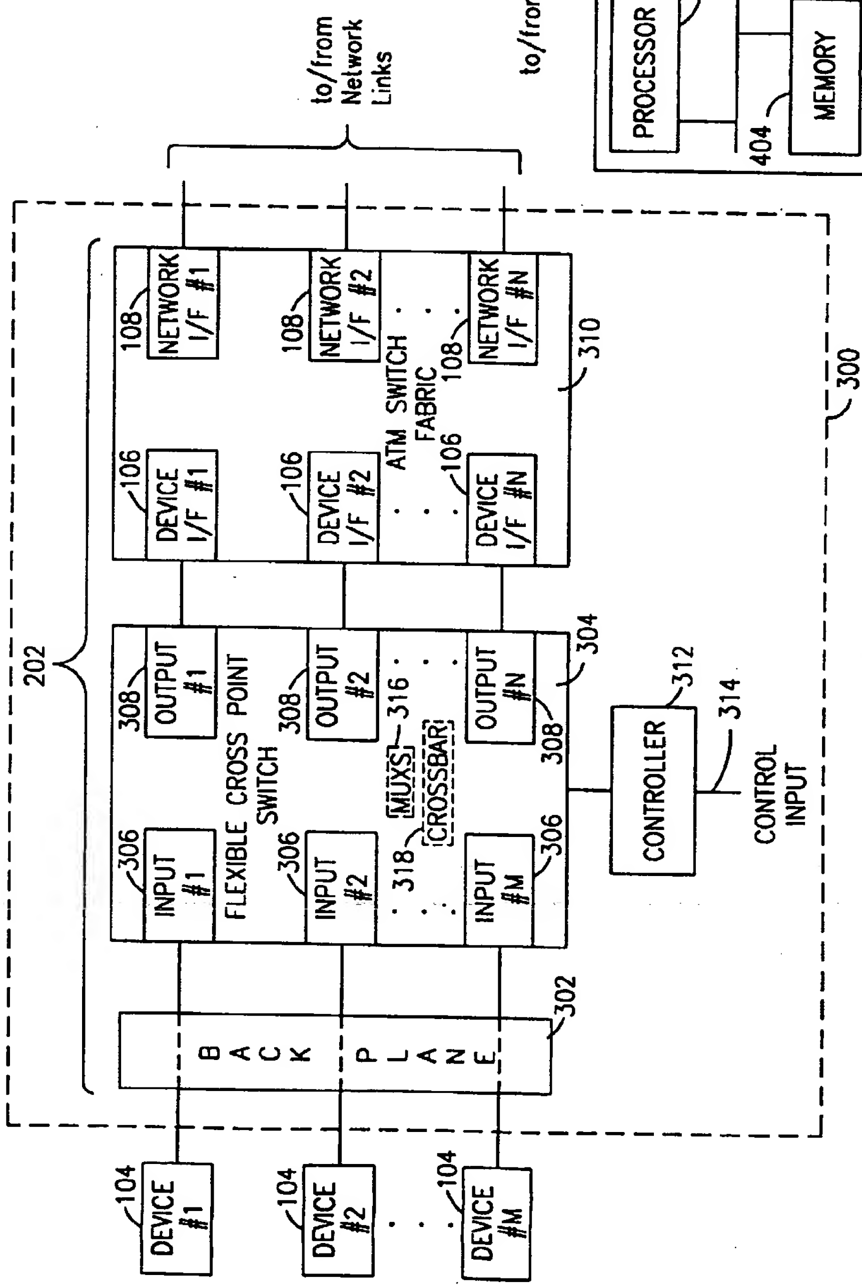

to/from Network Links
202
300
BACKPLANE
302
FLEXIBLE CROSS POINT SWITCH
304
INPUT #1
INPUT #2
INPUT #M
306
OUTPUT #1
OUTPUT #2
OUTPUT #N
308
MUXS
316
CROSSBAR
318
CONTROLLER
312
CONTROL INPUT
314
ATM SWITCH FABRIC
310
DEVICE I/F #1
DEVICE I/F #2
DEVICE I/F #N
106
NETWORK I/F #1
NETWORK I/F #2
NETWORK I/F #N
108
DEVICE #1
DEVICE #2
DEVICE #M
104

FIG. 3

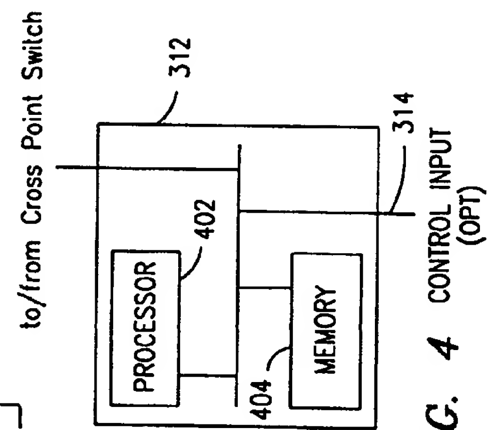

to/from Cross Point Switch
312
314
CONTROL INPUT (OPT)
PROCESSOR
402
MEMORY
404

FIG. 4

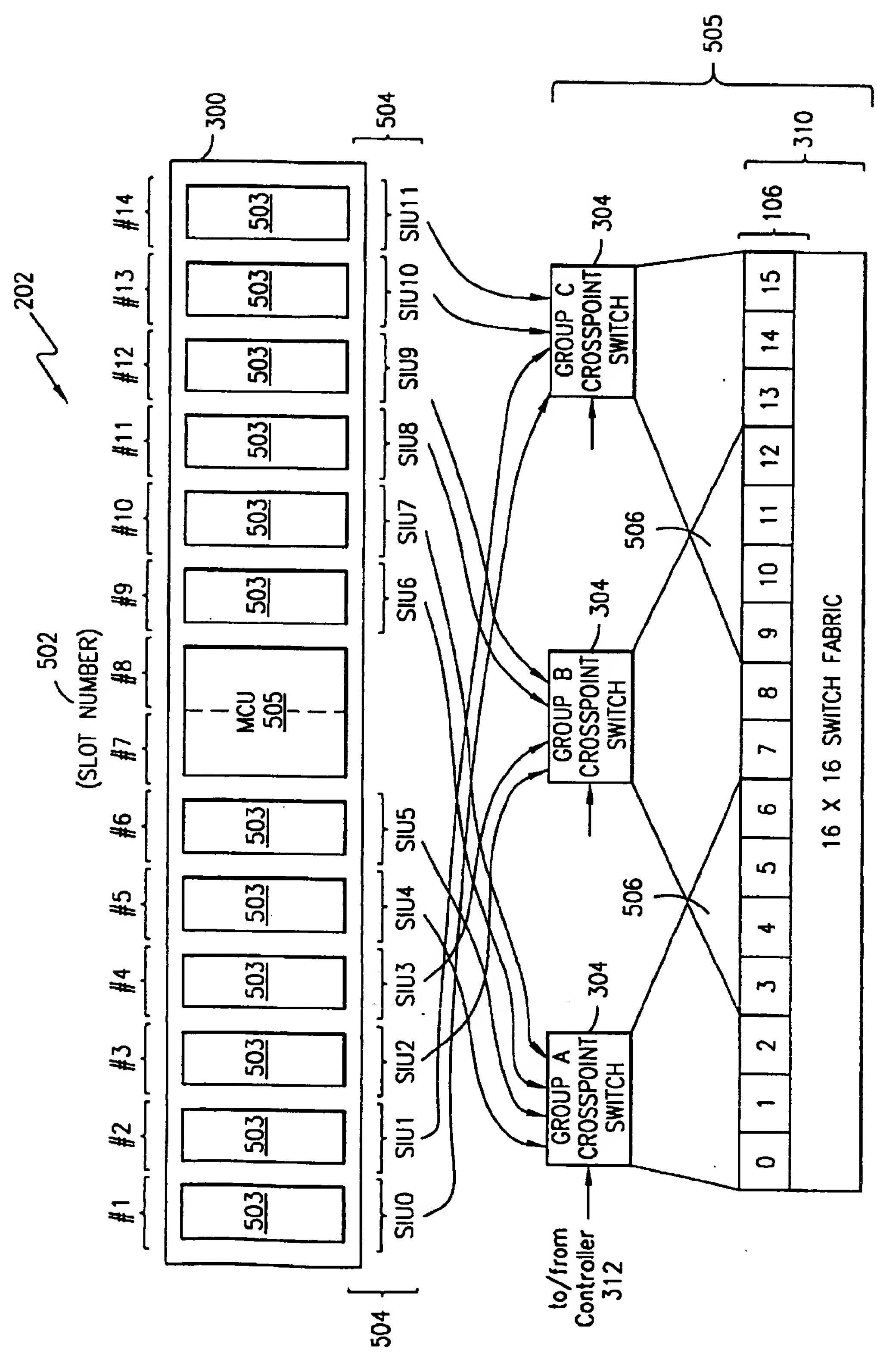

202
502
(SLOT NUMBER)
#1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #11 #12 #13 #14
300
503
MCU
505
504
SIU0 SIU1 SIU2 SIU3 SIU4 SIU5 SIU6 SIU7 SIU8 SIU9 SIU10 SIU11
to/from Controller 312
GROUP A CROSSPOINT SWITCH
GROUP B CROSSPOINT SWITCH
GROUP C CROSSPOINT SWITCH
304
506
505
310
106
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
16 X 16 SWITCH FABRIC

FIG. 5

METHODS AND APPARATUS FOR FLEXIBLE DEVICE INTERFACE PORT ASSIGNMENT IN A DATA COMMUNICATIONS SWITCHING SYSTEM

FIELD OF THE INVENTION

The present invention relates to data communications, and more particularly, to methods and apparatus for connecting a plurality of devices to a data communications network through a switching system.

BACKGROUND OF THE INVENTION

Asynchronous Transfer Mode (ATM) is becoming an important standard for communications around the world. One reason for this is that ATM is essentially the only established standards based technology that has been designed from the beginning to accommodate the simultaneous transmission of data, voice and video. ATM is essentially a connection-oriented, switched based technology that provides dedicated bandwidth for each connection, a higher aggregate bandwidth, well defined connection procedures, and flexible access speeds ranging from Megabit to Gigabit speeds.

An ATM network basically consists of several ATM switches that are interconnected by various communication links. A typical ATM switch includes a programmable switch matrix or switch fabric that supports the interconnectivity for both local devices and other remote ATM switches and devices. The flexibility of the switch fabric allows for virtual circuits to be established between nodes using switching protocols and commands. Depending upon the type of transfer, these virtual circuits provide point-to-point connections that can be unidirectional or bidirectional. In this manner, an ATM network is essentially woven using the switch fabric provided by the various ATM switches.

FIG. **1** is a block diagram depicting a typical ATM network **100** having an ATM switch **102** that provides network connectivity for several devices **104**, for example, numbered 1 through N. Devices **104** can include computers, hosts, routers, gateways, peripherals, appliances, and other like devices that are configured to send and/or receive the type of information (e.g., data, voice, video) carried by ATM network **100**.

As shown, devices **104** are each connected to a dedicated device interface port **106** (numbed 1 through N) within ATM switch **102**. On the network side of ATM switch **102**, there are several network interface ports **108** (also, numbered 1 through N). ATM switch **102** provides the switch fabric that selectively connects together (and later disconnects) specified device interface ports and/or network interface ports to help establish a virtual circuit though ATM network **100**. For example, in FIG. **1**, a virtual circuit is depicted by the solid and dashed lines connecting device (#2) **104** to remote device **110**, through ATM switch **102** and network links **112**. Network links **112** typically includes one or more communication media, such as, for example, terrestrial and/or satellite communication lines/services.

As further depicted in FIG. **1**, ATM switch **102** is limited in the number of devices **104** that can be supported by the "N" number of device interface ports **106** and the size of the switch fabric (i.e., N×N). For example, certain ATM switches provide a 16×16 switch fabric (i.e., where N=16) having sixteen device interface ports **106** and sixteen network interface ports **108**. As such, these ATM switches are limited to supporting sixteen devices **104**. Larger ATM switches are available, for example, 32×32 switch fabrics are provided by certain manufacturers. These 32×32 and even larger ATM switches, however, tend to be very complex and expensive.

As can be appreciated, the fixed size and high cost of an ATM switch, can be problematic for users that want to "phase-in" an ATM network and/or provide for future expansion of the ATM network, for example, by adding additional devices to the ATM switch. Indeed, users, such as small businesses, that have limited communication funds may be forced to forego the development of an ATM network until such time as they can justify the purchase of a larger ATM switch. Other users may be forced to purchase too large an ATM switch. In a worse case scenario, the large ATM switch that is purchased exceeds their current demands, but will eventually lack the capacity to support their future growth and additional demands. Thus, there is a need for methods and apparatus that provide a more flexible and cost-effective ATM switching capability.

SUMMARY OF THE INVENTION

The methods and apparatus of the present invention provide a more flexible and cost-effective switching capability by allowing device interface ports within a switch fabric to be dynamically assigned in a manner that allows several devices to selectively access a single device interface port.

Thus, for example, assume that a user has a current need to provide connectivity for twelve devices. Assume also that the user plans to expand that need to twentyeight devices in the future. In the past, such a user might decide to incrementally purchase two 16×16 switches, or initially purchase one larger 32×32 switch. Both of these choices tend to be rather expensive and wasteful. Given the present invention, however, such a user can purchase one 16×16 switch, for example, and economically add configurable connections that allow up to about forty-eight devices to access the network through the 16×16 switch.

With this example in mind, in accordance with certain aspects of the present invention, flexible network connectivity is provided to a plurality of devices through a network interface that can be dynamically configured and reconfigured as needed, without interrupting existing network connections, to meet the current communication needs of the user.

In accordance with other aspects of the present invention, the various methods and apparatus provided allow a data communication system to exceed the network connectivity capabilities of a conventional network switch.

In accordance with still other aspects of the present invention, the various methods and apparatus provided allow for incremental growth of a system to more cost-effectively meet the users communication needs.

In accordance with further aspects of the present invention, the various methods and apparatus provide a lower cost solution to connecting a plurality of devices to a network through a limited number of communication paths.

In accordance with still further aspects of the present invention, the various methods and apparatus provided tend to reduce the complexity of a network switch by significantly reducing the size of the switch fabric therein, for example.

In accordance with additional aspects of the present invention, the various methods and apparatus provide enhanced configuration capabilities that can be used to

automatically test various switch and network configurations and connections.

By way of example, the above stated needs and others are met by an apparatus for selectively connecting a plurality of external devices to a network, in accordance with certain embodiments of the present invention. The apparatus includes a selector and a switch. The selector has a plurality of input ports and a plurality of output ports. In certain preferred embodiments, the number of input ports within the selector is greater than the number of output ports within the selector, for example, certain selectors have at least about forty-eight input ports and at least about sixteen output ports.

While each of the input ports is configured to be connected to a different external device, the selector is dynamically configurable to selectively couple at least one of the input ports to at least one of the output ports. Thus, for example, at least one of the forty-eight input ports, or a subset thereof, can be selectively coupled to at least one of the sixteen output ports, or a subset thereof. This allows several devices to gain access to the network, without requiring a dedicated device interface port within the switch for each of the devices.

The switch has a plurality of device interface ports, for example "N" number, each of which is coupled to a corresponding output port in the selector. The switch is configured to switchably connect an individual device interface port to an identified network interface port, and thereby connect a particular device to the network through the identified network interface port.

In accordance with still other embodiments of the present invention, the selector is configured to be responsive to commands that are received through one of the input ports or output ports or through a separate control input. The commands cause the selector to be dynamically configured or reconfigured. For example, the selector can include a controller that is operatively configured to respond to the commands and dynamically reconfigure the selector such that a specified input port is connected or otherwise assigned to a specified output port. Additionally, the selector can also be configured to selectively couple at least one of the input ports to at least another one of the input ports, and/or at least one of the output ports to at least another one of the output ports. In this manner, enhanced loop-back types of diagnostic testing/evaluation, or even non-conventional connections or virtual circuits, can be realized.

In accordance with other embodiments of the present invention, a method is provided for connecting at least one external device to a network. The method includes the steps of connecting the external device to an input port of a selector, dynamically configuring the selector to selectively connect the input port to an output port within the selector, and connecting the output port to a device port in a switch. The method further includes the step of causing the switch to connect the device port to a network.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present invention may be had by reference to the following Detailed Description and appended claims when taken in conjunction with the accompanying Drawings wherein:

FIG. 1 is a block diagram depicting a network having a conventional ATM switch that is capable of supporting N number of devices using N number of device interface ports;

FIG. 2 is a block diagram depicting a network having a flexible ATM switch that is capable of supporting M number of devices using N number of device interface ports, wherein M>N, in accordance with certain embodiments of the present invention;

FIG. 3 is a block diagram depicting a flexible ATM switch, as in FIG. 2, for example, having a cross point switch that can be dynamically configured to selectively connect an Mth device to an Nth device interface port, in accordance with certain embodiments of the present invention;

FIG. 4 is a block diagram depicting a controller for use within a flexible ATM switch, as depicted in FIG. 3, for example, in accordance with certain embodiments of the present invention; and

FIG. 5 is a system diagram of an exemplary flexible ATM switch and the physical and/or functional relationship between a plurality of cross point switches, a backplane and the device interface ports of an ATM switch fabric, in accordance with certain embodiments of the present invention.

DETAILED DESCRIPTION

While the following exemplary embodiments are described with respect to an ATM network and associated devices, it is to be understood that the methods and apparatus of the present invention can be applied to other types of networks and devices.

With this in mind, FIG. 2 is a block diagram depicting an ATM network **100'** having a flexible ATM switch **202**, in accordance with certain embodiments of the present invention. Although similar to ATM network **100** as depicted in FIG. **1**, ATM network **100'** has the capability to provide connectivity to an increased number, (i.e., M) of devices **104** using flexible ATM switch **202**.

As described in greater detail below, flexible ATM switch **202** is dynamically configurable, for example, to selectively connect/disconnect specific devices **104** to/from a specific device interface port **106** in the ATM switch fabric. Thus, flexible ATM switch **202** can be configured and reconfigured on the fly, for example, based on commands from one or more controlling programs running on a local host and/or external host processor. In this manner, devices **104** are dynamically assigned to access the network through a specific device interface port **106**.

The ability to reconfigure the connections between devices **104** and flexible ATM switch **202** allows several devices to share one or more device interface ports. By way of example, device **104** (#1) and device **104** (#2) can be configured to selectively share device interface port (#1) **106**. Thus, depending upon the current configuration of flexible ATM switch **202**, either device (#1) or device (#2) would be connected to device interface port (#1) and thereby to ATM network **100'**.

FIG. 3 is a block diagram depicting an exemplary component chassis **300** having a flexible ATM switch **202** arranged therein, in accordance with certain embodiments of the present invention. As shown, flexible ATM switch **202** includes a backplane **302**, a cross point switch **304**, a switch fabric **310**, and a controller **312**. Backplane **302** provides a termination point for connecting devices **104** to flexible ATM switch **202**. Backplane **302** passes various signals between cross point switch **304** and devices **104**, preferably without significantly altering the signals.

In certain preferred embodiments, backplane **302** incorporates conventional connector terminals as required by devices **104**. The connections that pass signals between these connector terminals and cross point switch **304** are specifically manufactured to substantially rigid requirements

to control/match the impedance and/or resulting signal delays. For example, in certain embodiments, backplane **302** is configured to carry about 480 different electrical signals (for M=48 different devices **104**) through conductive traces, each of which is substantially the same length, (e.g., 12±0.25 inches).

Cross point switch **304** includes input ports **306** and output ports **308**. The naming convention used for input ports **306** and output ports **308** is not meant to restrict or otherwise classify the types of signals or connections provided by the respective ports. Instead, the naming convention, (i.e., "input" and "output") are employed simply to specify their illustrated location with respect to devices **104**. Thus, input ports **306** and output ports **308** can include unidirectional (either input or output) and/or bidirectional connections.

As depicted, an individual input port **306** is provided for each of the devices **104** that is to be supported by flexible ATM switch **202**. Thus, for example, in certain exemplary embodiments forty-eight input ports **306** are provided in cross point switch **304** to support up to about forty-eight different devices **104**. Of course, the number of devices and input ports **306** can vary depending upon the desired arrangement, (i.e., M>1).

Cross point switch **304** is configured to selectively connect/disconnect an individual input port **306** to/from an individual output port **308**. In this manner, for example, a given device **104** can be coupled to, or otherwise assigned, a specific output port **308**, through backplane **302** and a dedicated input port **306**. As shown, each of the output ports **308** is further connected to a corresponding device interface port **106** in switch fabric **310**.

One important feature of cross point switch **304** is that two or more devices **104** can be made to selectively access one or more of the device interface ports **106** in switch fabric **310**, as determined by the configuration of cross point switch **304**. Thus, it is preferred that the number (M) of input ports **306** be greater than the number (N) of output ports **308**. For example, in certain exemplary embodiments, cross point switch **304** includes forty-eight input ports **306** and sixteen output ports **308** (i.e., M=48, N=16). Thus, using this 48x16 (MxN) cross point switch **304**, up to about forty-eight different devices **104** can be selectively supported by a switch fabric **310** having only sixteen device interface ports **106** and sixteen network interface ports **108**.

Of course, in this example, not all of the forty-eight devices can be connected to the network at the same time, because there are only sixteen network interface ports **106** provided, hence the term "selectively" connected. For many network arrangements, wherein devices **104** may sit idle for extended periods of time before requiring access to the network, being selectively connected/disconnected to/from one or more device interface ports **106** does not appear to significantly impact on the performance of the network arrangement and/or device. This is especially true given the speed associated with the dynamic reconfiguration capability of certain preferred cross point switches.

It is further recognized, that larger arrangements, or conversely, smaller arrangements, can benefit under the present invention. For example, a 48x32 cross point switch **304** can be used along with a larger 32x32 switch fabric to provide additional connectively, (i.e., up to thirty two devices **104** can be connected to the network at the same time). Thus, larger (or smaller) cross point and/or multiple cross point switches can be employed as required.

As shown in FIG. **3**, each of the output ports **308** is connected to a corresponding device interface port **106** within switch fabric **310**. Switch fabric **310** is configured to switchably connect/disconnect device interface ports **106** with network interface ports **108**. Switch fabric **310** is responsive to ATM protocol based commands in building connections, or tearing down existing connections, between a specified device interface port **106** and a specified network interface port **108**. In this manner, for example, switch fabric **310** completes the connection between a device **104** and remote device **110** (see FIG. 2). As such, in accordance with certain embodiments of the present invention, switch fabric **310** is a conventional (NxN) switch fabric or matrix, as found in many of the ATM switches available today.

Controller **312** is configured to control the connection/disconnection functions provided by cross point switch **304**. More particularly, controller **312** monitors the status of cross point switch **304** and is responsive to commands received from one or more external control processes in configuring and reconfiguring the connections provided by cross point switch **304**.

Thus, for example, a controller **312** is depicted in the block diagram of FIG. **4**, in accordance with certain preferred embodiments of the present invention. Controller **312** includes a processor **402**, memory **404**, and associated software (not depicted). Processor **402** is responsive to commands received, for example, over one of the input ports **306**, output ports **308**, and/or a separate control input **314**. Software instructions are provided to processor **402** that cause processor **402** to build and/or maintain a database that includes a configuration map associated with cross point switch **304**.

The configuration map, which can be stored within memory **404**, for example, includes a port configuration for each of the input ports **306** and output ports **308**, (e.g., device number, type, pin assignments, etc.) and the current connections between input ports **306** and output ports **308**.

Controller **312**, based on the configuration map, the commands received, and/or the current status of cross point switch **304**, provides one or more controlling signals to cross point switch **304** that cause certain connections to be made and/or broken. By way of example, controller **312** can output a JTAG or similar bit stream to cross point switch **304** that causes input port (#1) **306** to be disconnected from output port (#1) **308**, and reconnected to output port (#2) **308**. Once this reconfiguration has been accomplished, the configuration map is updated to reflect the changes.

It is preferred that cross point switch **304** be dynamically reconfigurable such that individual changes can be made without disrupting the communications on other established connections. Thus, in the reconfiguration example above, when input port (#1) **306** is disconnected from output port (#1) **308** and reconnected to output port (#2) **308**, an existing connection between input port (#2) **306** and output port (#N) **308** is not disrupted.

With the addition of cross point switch **304**, flexible ATM switch **202** is further capable of providing enhanced loop-back connections. For example, in certain embodiments, cross point switch **304** can connect an input port **306** to another input port **306**. Similarly; cross point switch **304** can connect an output port **308** with another output port **308**. These types of loop-back connections can be of particular use when testing switching, network connectivity, and/or various components/devices. Thus, for example, in addition to providing controls to controller **312**, a network manager process running on remote device **110** can also check on the operation of the network and/or switch fabric **310** using a loop-back connection between output port (#1) **308** and

output port. (#2). In another example, a local system management function can check the various device/backplane connections and/or the operation of cross point switch **304** by using a loop-back connection between input port (#1) **306** and input port (#2) **306**.

Those skilled in the art will recognize that these and other functions can be provided within flexible ATM switch **202**, and in particular within cross point switch **304**, using conventional controlled, high-speed switching techniques/circuits. For example, in accordance with certain embodiments of the present invention, cross point switch **304** includes a plurality of multiplexers (MUXs) **316** connected between input ports **306** and output ports **308**, such that one or more signals from an individual input port **306** can be connected to a specified output port **308**, based on a control signal(s) from controller **312**.

By way of a further example, in accordance with still other embodiments of the present invention, cross point switch **304** includes at least one crossbar switch or circuit. **318** that is connected between input ports **306** and output ports **308**, such that one or more signals from an individual input port **306** can be connected to a specified output port **308**, again, based on a control signal from controller **312**.

It is further recognized that certain embodiments of flexible ATM switch **202** can include several cross point switches **304** that are configured to service specific input ports **306** and specific output ports **308**. Thus, in accordance with certain preferred embodiments of the present invention, flexible ATM switch **202** can have several cross point switches **304** that are arranged to support a specific subset of the devices **104**. Furthermore, a plurality of controllers **312** can also be employed to control the different cross point switches.

FIG. **5** is a system diagram of an exemplary flexible ATM switch **202** that depicts the physical and functional relationship between a plurality of cross point switches **304**, a backplane **302** and the device interface ports **106** of an ATM switch fabric **310**, in accordance with certain preferred embodiments of the present invention. In this exemplary embodiment, M=48 and N=16.

As shown, within chassis **300** there are a plurality of standard plug-in card slots **502**, numbered one through fourteen. Twelve of the slots **502**, i.e, those numbered one through six and nine through fourteen, are each configured with a line interface card **503**. Each line interface card **503** provides interface support for up to four different devices **104** through dedicated ports in backplane **302**. Two of the slots **502**, i.e, those numbered seven and eight, are configured to support a main control unit (MCU) **505** having a plurality of cross point switches **304**, at least one controller **312**, and a N×N switch fabric **310**.

As further depicted, each of the line interface cards **503** is assigned to a subscriber interface unit (SIU) **504**, for example, numbered zero through eleven. In this manner, forty-eight different devices **104** can be supported, i.e, up to four devices **104** being supported through each SIU **504**.

In accordance with certain preferred embodiments of the present invention, groups of SIUs **504**, and therefore groups of devices **104**, are assigned to one or more of the plurality of cross point switches **304**. For example, as shown in FIG. **5**, the SIUs **504** can be divided into three groups, namely groups A, B and C. Group A includes four SIUs **404**, numbered four, five, six, and seven. Group B includes four SIUs **504**, numbered two, three, eight, and nine. Group C includes the remaining four SIUs **504**, numbered zero, one, ten, and eleven.

In this exemplary embodiment, there are at least three cross point switches **304** provided, one for each of the groups A, B and C. The output ports for each cross point switch **304** are connected to corresponding device interface ports **106** in the switch fabric **310**.

Thus, for example, the cross point switch **304** that supports group A has up to sixteen input ports and seven output ports. The seven "group A" output ports are connected to seven corresponding device interface ports **106**, i.e., numbered zero through six in FIG. **5**. The cross point switch **304** that supports group B, for example, has up to sixteen input ports and ten output ports. The ten "group B" output ports are connected to ten corresponding device interface ports **106**, i.e., numbered three through twelve in FIG. **5**. Similarly, the cross point switch **304** that supports group C, for example, has up to sixteen input ports and seven output ports. The seven "group C" output ports are connected to seven corresponding device interface ports **106**, i.e., numbered nine through fifteen in FIG. **5**.

As described above and graphically depicted by the overlapping regions **506** in FIG. **5**, in this exemplary embodiment many of the device interface ports **106** within switch fabric **310** are connected to output ports from at least two of the plurality of cross point switches **304**. These device interface ports **310** are, therefore, essentially "shared" between groups.

Thus, for example, referring to FIG. **5**, the device interface ports **106**, numbered three through six are each shared by the "group A" output ports and the "group B" output ports. Likewise, the device interface ports **106**, numbered nine through twelve are each shared by the "group B" output ports and the "group C" output ports.

The use of these shared device interface ports is selectably controlled by controller **312**, (e.g., see FIGS. **3** and **4**). As such, no more than one of the cross point switches **304** is allowed to operatively use a shared device interface port **106** at a given time.

One of the functional advantages to grouping devices **104** and/or sharing device interface ports **106** between two or more cross point switches **304**, is that certain devices **104** can be provided with different levels of service. By way of example, the devices in group B may have a higher probability of accessing the network than the devices in groups A or C, because the cross point switch **304** that supports the group B devices has access to more device interface ports **106** within switch fabric **310**.

Although certain embodiments in accordance with the present invention, are depicted in the accompanying Drawings and described in the foregoing text, it should be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

What is claimed is:

1. A switching apparatus capable of selectively coupling M external devices to a communication network, said switching apparatus comprising:

an N×N output switching stage having N input interfaces and N output interfaces, wherein said N output interfaces are capable of being coupled to said communication network;

a programmable M×N input switching stage having M input ports and N output ports, wherein M is greater than N, and wherein each of said M input ports is capable of being coupled to one of said M external

devices and each of said N output ports is coupled to one of said N input interfaces of said N×N output switching stage; and

a controller capable of controlling said programmable M×N input switching stage such that each one of said M external devices may be selectively coupled and decoupled to one of said N input interfaces of said N×N output switching stage according to a level of service associated with said each one of said M external devices.

2. The switching apparatus as set forth in claim 1 wherein said N×N output switching stage comprises an N×N asynchronous transfer mode (ATM) switch fabric.

3. The switching apparatus as set forth in claim 1 wherein said programmable M×N input switching stage comprises an M×N cross point switch.

4. The switching apparatus as set forth in claim 1 wherein said programmable M×N input switching stage comprises an M:N multiplexer having M input channels and N output channels.

5. A communication network comprising a plurality of switching apparatuses, each of said plurality of switching apparatuses capable of selectively coupling M external devices to internal network links of said communication network, wherein each of said plurality of switching apparatuses comprises:

an N×N output switching stage having N input interfaces and N output interfaces, wherein said N output interfaces are capable of being coupled to said internal network links of said communication network;

a programmable M×N input switching stage having M input ports and N output ports, wherein M is greater than N, and wherein each of said M input ports is capable of being coupled to one of said M external devices and each of said N output ports is coupled to one of said N input interfaces of said N×N output switching stage; and

a controller capable of controlling said programmable M×N input switching stage such that each one of said M external devices may be selectively coupled and decoupled to one of said N input interfaces of said N×N output switching stage according to a level of service associated with said each one of said M external devices.

6. The communication network as set forth in claim 5 wherein said N×N output switching stage comprises an N×N asynchronous transfer mode (ATM) switch fabric.

7. The communication network as set forth in claim 5 wherein said programmable M×N input switching stage comprises an M×N cross point switch.

8. The communication network as set forth in claim 5 wherein said programmable M×N input switching stage comprises an M:N multiplexer having M input channels and N output channels.

9. A switching apparatus capable of selectively coupling M external devices to a communication network, said switching apparatus comprising:

an N×N output switching stage having N input interfaces and N output interfaces, wherein said N output interfaces are capable of being coupled to said communication network;

a programmable P×Q input switching stage having P input ports and Q output ports, wherein each of said P input ports is capable of being coupled to one of said M external devices and each of said Q output ports is coupled to one of said N input interfaces of said N×N output switching stage;

a programmable R×S input switching stage having R input ports and S output ports, wherein each of said R input ports is capable of being coupled to one of said M external devices and each of said S output ports is coupled to one of said N input interfaces of said N×N output switching stage, wherein at least one of said S output ports may be coupled to the same one of said N input interfaces of said N×N output switching stage as one of said Q outputs of said programmable P×Q input switching stage; and

a controller capable of controlling said programmable P×Q input switching stage and said programmable R×S input switching stage such that each one of said M external devices may be selectively coupled and decoupled to one of said N input interfaces of said N×N output switching stage according to a level of service associated with said each one of said M external devices.

10. The switching apparatus as set forth in claim 9 wherein said N×N output switching stage comprises an N×N asynchronous transfer mode (ATM) switch fabric.

11. The switching apparatus as set forth in claim 9 wherein said programmable P×Q input switching stage comprises a P×Q cross point switch.

12. The switching apparatus as set forth in claim 9 wherein said programmable R×S input switching stage comprises an R×S cross point switch.

13. The switching apparatus as set forth in claim 9 wherein said programmable P×Q input switching stage comprises a P:Q multiplexer having P input channels and Q output channels.

14. The switching apparatus as set forth in claim 9 wherein said programmable R×S input switching stage comprises an R:S multiplexer having R input channels and S output channels.

15. A communication network comprising a plurality of switching apparatuses, each of said plurality of switching apparatuses capable of selectively coupling M external devices to internal network links of said communication network, wherein each of said plurality of switching apparatuses comprises:

an N×N output switching stage having N input interfaces and N output interfaces, wherein said N output interfaces are capable of being coupled to said communication network;

a programmable P×Q input switching stage having P input ports and Q output ports, wherein each of said P input ports is capable of being coupled to one of said M external devices and each of said Q output ports is coupled to one of said N input interfaces of said N×N output switching stage;

a programmable R×S input switching stage having R input ports and S output ports, wherein each of said R input ports is capable of being coupled to one of said M external devices and each of said S output ports is coupled to one of said N input interfaces of said N×N output switching stage, wherein at least one of said S output ports may be coupled to the same one of said N input interfaces of said N×N output switching stage as one of said Q outputs of said programmable P×Q input switching stage; and

a controller capable of controlling said programmable P×Q input switching stage and said programmable R×S

input switching stage such that each one of said M external devices may be selectively coupled and decoupled to one of said N input interfaces of said N×N output switching stage according to a level of service associated with said each one of said M external devices.

16. The communication network as set forth in claim **15** wherein said N×N output switching stage comprises an N×N asynchronous transfer mode (ATM) switch fabric.

17. The communication network as set forth in claim **15** wherein said programmable P×Q input switching stage comprises a P×Q cross point switch.

18. The communication network as set forth in claim **15** wherein said programmable R×S input switching stage comprises an R×S cross point switch.

19. The communication network as set forth in claim **15** wherein said programmable P×Q input switching stage comprises a P:Q multiplexer having P input channels and Q output channels.

20. The communication network as set forth in claim **15** wherein said programmable R×S input switching stage comprises an R:S multiplexer having R input channels and S output channels.

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